RECENT WORK OF THE INDIAN MARINE SURVEY.[1]

THE importance of the work intrusted to the Indian Marine Survey, alike from the point of view of the hydrographer, of the geologist, and of the zoologist, is so well known to all men of science that it would be mere waste of time to attempt to emphasise it on the present occasion. All the Reports that have from time to time been published by this Survey bear witness to the zeal and energy with which the work is carried on—frequently under circumstances of great difficulty—and to the capacity and accomplishments of the officers to whom it is entrusted. But it will be no reflection on previous documents of the same nature if we call attention to the special interest attaching to the one now before us, on account of the varied nature of the subjects on which it touches, the philosophical manner in which these are treated, and the problems presented by many of them.

The first section of the Report is by Commander T. H. Heming, R.N., who has entire charge of the Survey; and geologists will read with great interest his account of the rapid silting-up of the Gulf of Martaban that is now in progress. It appears that an enormous quantity of sediment is being carried into the Gulf by the Salween River; a sample of water taken at spring tide during the dry season yielding no less than 1/300th of dry mud by weight. The deposit has mainly taken place outside the 10-fathom line, and so heavy is it that in spots where there were formerly from 40 to 50 fathoms, the depth is now reduced to from 15 to 20; the area affected being approximately 2000 square miles. "Putting the amount of water discharged by the river flowing into the Gulf at a low estimate," says the Report, "and supposing it capable of supporting on the average one-quarter of the proportion of sediment held in solution [? suspension] by the specimen examined, there would be more than enough solid matter carried into the Gulf in forty years to cause the silting-up which has actually taken place."

Another point of interest in this section is the longitude of the Andamans, which, as deduced by running a meridian distance to Sugar-loaf Island, was found to differ by 1′ 70″ from that given by the Great Trigonometrical Survey. In consequence of this discrepancy it is now proposed to run a meridian distance between Port Blair and Diamond Island both ways, in order to obtain the best possible results with the means at disposal.

Passing on to the section of the Report written by the Surgeon-Naturalist, Captain A. R. S. Anderson, we may call attention to the remark as to the rapid change in the coloration and appearance of the animals of Ford Bay, Great Cocos Island, when the coral bottom of the open channel is left for the sandy bottom of the bay. While quarantined off Colombo a lucky haul brought up no less than forty-one examples of the rare crustacean *Lupocyclus orientalis*, of which only three specimens were previously known to science. In another haul, which brought up a miscellaneous collection of dead corals, sharks' teeth, fish-bones and bones of turtles, the interesting fact was discovered that while some of these were in practically the same condition as at the time of their deposition, others had been highly impregnated with mineral matter. No embedding in sediment had, however, preceded the fossilisation (if the term is permissible in this connection), which had evidently taken place as the bones lay loose on the sea-bottom.

In a haul taken some distance east of the Maldives, Captain Anderson was fortunate enough to procure over 200 specimens of an echinoderm nearly related to the West Indian *Palaeopneustes hystrix*, but apparently specifically distinct. When placed in spirit these urchins turned it a magnificent rich purple, although their own colour was a dull madder-brown. Many other rare and interesting invertebrates were obtained at other dredging stations, but we must omit mention of any of these to refer to a totally different subject.

Between Colombo and Rangoon an excellent opportunity was afforded of carefully observing the flight of the common flying-fish (*Exocoetus evolans*). "When they first rise from the water," writes the narrator, "they do so with a very rapid fluttering of their wings lasting for two to three seconds; they then soar along till their speed is so reduced that they descend and touch the water, into which they either fall with a splash or dip the elongated tip of the caudal fin, and, I think, the ventral fins on which they seem to poise themselves, again rapidly vibrate their wings, and get up sufficient speed to renew their flight; this process I have seen them repeat as often as seven times in the course of one long flight. Very occasionally, however, I have observed these fish fluttering their wings without touching the water with their caudal and ventral fins."

After mentioning that in order to observe these motions calm weather and a binocular are necessary, Captain Anderson proceeds to say that he fails to understand how Moseley, as narrated in his "Naturalist on the *Challenger*," as well as several other observers, have denied the fluttering of the wings in flying-fish. Apparently he is unaware that it has been stated in the "Royal Natural History" by the editor, as the result of personal observation, that these fish do possess the power in question, as indeed had been attested in *Land and Water* by a much earlier observer. Captain Anderson's observations also corroborate the statement made by the writer last referred to, that flying-fish are capable of altering the direction of their flight: an attribute that was denied to them by Dr. Möbius in his well-known account.

In a later paragraph Captain Anderson draws attention to the circumstance that in flying-fish the lower surface of the body is flattened in order to enable them the more easily to rise from and hover over the water, and that in the allied genus, Hemiramphus,[1] the members of which rush at full speed along the top of the water with only the hinder portion of the body immersed, a similar flattening is observable.

While lying in Burmese waters off Moulmein, the surveying vessel encountered a large quantity of drift-wood brought down by the Moulmein river. Some of this became entangled in the paddle-wheels, and on three mornings snakes were found on the floats. A female leopard, probably carried down by the strong tide, took refuge one morning on a cargo boat moored somewhat higher up, and eventually swam ashore, where she was shot. These instances are of much interest in connection with the dispersal of species.

Much of the latter portion of this section of the Report is occupied by an account of the author's experiences in the Andaman Islands, where he has much to say concerning both the natives and the fauna. In one passage he mentions that, while walking through the forest, a native announced the presence of a large mass of wild honey in the immediate neighbourhood, which he detected by its smell, although this was quite imperceptible to the European members of the party.

In conclusion, Captain Anderson refers to the remarkable circumstance that in the neighbourhood of the Andamans there occur masses of sandstone at a depth of between 39 and 226 fathoms which are quite bare of coral, although there is an abundant growth of the same in the immediate neighbourhood. It is inferred that the bare area, and probably also the larger portion of the bank, has never been within the zone of massive reef-building corals. "Had it ever been so, it is most improbable that there should be bare rock exposed at 39 fathoms. For that the bank is eminently suitable for the growth of coral, both the dredgings and the soundings, by bringing up live coral, showed; at no part of the bank was there any turbidity of the water sufficient to check coral-growth. . . . Were the theory correct that, given a bank rising within a comparatively short distance of the surface, deposit will accumulate on that bank and so form a basis for a coral island, there is no reason why, in the case of this bank, bare rock without any such deposit on it should be found."

Many other equally interesting and suggestive extracts might be culled from this valuable report did limitations of space permit.

R. L.

[1] Administration Report of the Marine Survey of India for the Official Year 1898–99. Pp. 17. (Bombay: Government Central Press, 1900.)

[1] A mis-spelling of this and several other names is noticeable in the Report, but, as the writer of this notice is well aware, much allowance must be made for an author whose copy is set up by native Indian printers.

THE TEACHING OF PHYSIOLOGY.

IT is scarcely too much to say that the only real scientific knowledge is that obtained through personal experience. Lectures and text-books have their places in a scheme of instruction in science, but they only convey information at second-hand, whereas original experimental work creates and fosters the inquiring spirit characteristic of a progressive mind. What students need to be taught is that they must be not so much receptive as constructive; and the way to give force to this view is to insist upon their taking an active share in investigation at

every stage of their careers. It is in the highest degree satisfactory to know that this principle is being acted upon in the courses of scientific instruction followed in many of our schools and colleges—more particularly in the Schools of Science and Higher Elementary Schools of the Board of Education. But a large class of students of a higher grade are introduced to scientific subjects on the old-fashioned plan, the reason in most cases being that they have no time to pursue a course of work constructed on rational lines. Metaphorically, they endeavour to enter the field of science by a short cut instead of following the route of patient and persistent observation, and in the end they find themselves without the certificate of admittance into the Delectable City. Medical students are the greatest sinners in this respect, but the fault lies not so much with them as with their masters and examiners. So many subjects have to be taken that it seems almost hopeless to look for greater opportunity for investigation or for the development of a spirit of research in students whose knowledge of practical chemistry is obtained by a few hours' test-tubing. In the teaching of physiology, also, there is a great gap between rational methods and existing practice, and Dr. W. T. Porter, associate professor of physiology in the Harvard Medical School, directs attention to it in an article which we reprint, slightly abridged, from the special educational number of the *Philadelphia Medical Journal*. Dr. Porter shows, in addition, how large classes of students may be carried along the well-known roads that lead to scientific power, and gives the results of one year's experience with a method of instruction different from that usually employed. His paper thus contains a statement of a course which has been proved to be practicable, and has been accepted by the Faculty of the Harvard Medical School. The methods described need not, however, be limited to medical education, as they are based upon principles which, *mutatis mutandis*, can be applied to instruction in any science. The paper is thus worthy of consideration by every one interested in the extension of natural knowledge.

To the physician the study of physiology is of use largely because it creates a habit of thought essential to the highest professional success. Physiology is a *rational* science. Its problems require the scientific method. They demand the precise statement of the question in hand, a severely critical examination of the results of experiments, and the arrangement of the accepted experiments in the order that shall lead logically, step by step, to a correct solution. Medicine is itself an experimental pursuit. Its higher walks are open only to those skilled in research. The scientific method cannot be acquired by the study of anatomy and pathology in the purely descriptive form in which they ordinarily are presented to the medical student; in this form they are stuff for visual and aural memory —not for the exercise of reason. Nor can the experimental state of mind be readily acquired by the study of clinical medicine. Reliance must be placed on a well-developed, highly rational science, cultivated to train rather than inform the mind, pursued, not for its stores of information, but for the highest product of human faculty—the system of inquiry that leads to light through darkness. Too often in our medical schools information is mistaken for knowledge. Only knowledge is power. The getting of mere information wastes the student's time. The vast accumulations of centuries of medical study confuse the undisciplined mind and crush the spirit. The burden of fact which any man can bear is relatively small, and each year grows relatively smaller. To find new truths and to look undismayed upon the old is the perfect fruit of education. This physiology can give, and on this power to train should rest the high position of physiology in schools of medicine.

The physiological lectures in medical schools are commonly given by one man and cover the entire field of physiology. This field is much too large to permit of even superficial personal acquaintance by one man. Necessarily, therefore, the instructor must take the chief part of his lecture from text-books. To this he adds citations of a few experiments or observations taken from the original sources. He has not and cannot have real knowledge as to the present state of special opinion on the majority of the chapters in his subject, because none but a specialist can cope with the constantly rising flood of meritorious research in any one chapter—to keep pace with the whole of a science which stretches ample arms over the larger part of human and comparative biology is impossible. Physiology could not be taught by the lectures now so largely given, even were lecturers gifted with superhuman knowledge. Physiology deals with phenomena, not with words. Many of these phenomena, for example the heart-sounds, cannot be described; others can be pictured dimly, but only to those who know related phenomena from having actually seen or otherwise sensed them; in no case can lectures properly instruct unless the fundamental facts or closely related facts have first been learned by actual observation in the laboratory. The student should come to the lecture already possessed by his own efforts of the phenomena to be discussed. Chapters, such as metabolism, in which the fundamental experiments are unusually difficult or protracted, should be preceded by less difficult though related chapters. If the obstacles to practical work in any field are insurmountable, the protocols of classical experiments in this field, together with a suitable connecting text, should be studied before the lecture. At present the lecturer too often merely offers a list of facts which mean little or nothing because they cannot be associated in the student's mind with phenomena already observed. The lecturer attempts to remind the student of that which the student never knew. The secondary schools have prepared the student to see nothing strange in this. Most men enter the physiological course persuaded that natural science can be acquired chiefly from books, and leave convinced that a deal of talk and a pennyworth of nature will give real knowledge of the action of living tissues.

A natural science cannot be well taught except by those who have themselves made experimental investigations in the special field which they would teach. No one in these days can work profitably in many fields, and only necessity should make one man attempt to teach them all. A man trained, for example, in the physiology of digestion is likely to have but a relatively feeble grasp on the physiology of the circulation, and nervous system, or the special senses. It follows that most of the instruction in the one-man system does not adequately represent the present state of knowledge. It is behind the times in all except the special field cultivated by the instructor himself. So far as possible, the didactic instruction in each field should be given by the member of the physiological staff actively at work therein, but this wise principle of the division of labour is not usually regarded.

Passing now to the demonstrations, we find that in the larger schools they are made before an audience of at least two hundred. Thus the greater number cannot see the demonstration clearly. If the class be divided into small sections, the brief glimpse allowed each man does not suffice for a full grasp of the details. Very commonly the demonstrations requiring much time are given in a course separate from the lectures. In short, most of the demonstrations as now given are an aid to the memory rather than a means of training in science. The position awarded them by the usual lecturer and by almost every student is one of the evidences of the fundamental pedagogical error which renders most medical teaching of anatomy and physiology so largely futile, namely, the deplorable notion that demonstrations are merely illustrative, and the book and the lecture the main force. Never was the pedagogical cart more squarely before the horse. Contact with nature is the essential of all training in biology.

The laboratory work in large schools is usually done in relatively small sections, and is not coordinated with the regular lecture course. The student feels that the experiments are purely secondary. The experiments are imperfectly arranged into groups. They merely illustrate the text-book. In no case do they present a full picture of any field. The time allowed is so short that criticism of results and insistence upon the proper standard of excellence is not attempted.

The instruction is the same to every student without regard to what his life is to be. Much time is given to matters which have a very remote connection with the future of most students, and which are not better material for training the mind than matter bearing directly on the student's future work.

It is important to inquire how this extraordinary system was developed. The reply is that the present method is a survival of mediæval methods; the student of tradition finds a rich field in the history of medical teaching. The teaching of physiology has broken away from anatomy; men now living have taught both subjects in the same course of lectures. Descriptive anatomy became the most conspicuous discipline in medicine at a time when the best mental training could be had only from books, from lectures, from abstractions. It was the flowering time of metaphysics, of authority, of the deductive method. The true principle of approaching nature discovered by the

Greeks survived only in a few men of genius, a spark that in our own time has been fanned into flame. Joined to the powerful example of the most liberal education of that period was the difficulty of obtaining material for dissection. Stark necessity united with specious theory to fasten upon this most concrete of sciences the methods of the schoolmen, and to this day the bulk of the instruction in anatomy remains didactic, and consists of books, diagrams, and more or less misleading models. Dissections are made to illustrate the book. The printed description is learned by rote, and the dissection practised too often simply as a manual exercise. The anatomy of the medical college is largely a memory drill—such as belongs pedagogically in the secondary schools. These seventeenth-century notions have been passed from anatomy to physiology. That which began as a makeshift has become a dogma.

Practical work in physiology has also been kept back by the erroneous ideas that the cost of apparatus and other materials is prohibitory, that medical students cannot master the details of exact experimentation, that delicate apparatus cannot be trusted in their hands, and that instruction to the extent required cannot be given to large classes because the course will become too complicated to be carried out.

Perhaps the chief obstacle which has kept physiology in an ancient and now almost abandoned path, is the public belief that because anatomy and physiology were once taught chiefly from books, they should still be so taught; that the functions of living organs can be learned from books with the occasional exhibition of dead organs; that the natural sciences should continue to be studied in secondary schools without laboratory work; in brief, that nature can be studied apart from nature. The public has a just contempt for men who profess to have learned disease without practical observation of the sick—experience is conceded to be necessary here—but the public is ready to applaud, and even to compel by law the study of the same organs in their normal state by reading or hearing a description at second hand of what some third person saw. The real drags upon progress are the failure of the secondary schools to teach science by scientific methods, and the fatal conservatism that binds teachers of medicine to a past that we should do well to forget. These venerable delusions no longer impede experts in pedagogy, but unfortunately medical teachers for the most part are more zealous than learned in pedagogy. They fail to see that medical training should be "for power," and only secondarily for information.

If it be replied to these strictures that a system which produces so many able physicians cannot be much in need of improvement, I answer that the men of talent veil the defects of the mass. They owe much to themselves; genius will thrive on the intellectual diet that stunts the merely industrious man. The average student does not build upon a sound foundation. He knows little anatomy, less physiology, and still less chemistry, and even his training in practical medicine has to be supplemented where possible by postgraduate work in a hospital. On the whole, it may be said that his industry has been largely misdirected.

The picture I have drawn of the instruction in physiology in the average medical school will be accepted by teachers of that science. The sense that the usual methods of instruction neither develop nor much inform the mind is general. Careful inquiry should therefore be made to determine how far the defects can be remedied with the means at our disposal. The problem is: How far can the correct theory be realised in practice? To what extent can all students of physiology be taught in the manner in which men are trained to be professional physiologists? Evidently physiologists are likely to study their own subject in the most profitable and labour-saving way.

The expansion of physiology has broken it into specialities. Even professional physiologists can no longer have personal acquaintance with the whole subject, or even a relatively large part of it. To a considerable degree the physiologist himself must acquire his information from reading the work of others. It would therefore be idle to expect the student to get a personal experimental knowledge of the whole subject. His limited time must be used chiefly for training, and not chiefly for the acquisition of facts, as at present, and this training must follow the lines laid down by physiologists for their own development.

Deal so far as possible with the phenomena themselves, and not with the descriptions of them. Where the fundamental experiments cannot all be performed, fill the gap with the original protocols from the classical sources. Associate facts which the student can observe for himself with those which he cannot observe. Use as the basis of professional instruction, where practicable, the facts and methods to be used by the student in earning his living. Teach the elements by practical work. Let the student state his observations and results in a laboratory note-book, which, together with the graphic records of his experiments, shall form one of the requirements for the degree. Control his progress and remove his difficulties by a daily written examination and a daily conference, in which the instructor shall discuss the observations made by the student and supplement them from his own reading. Stimulate the student by personal intercourse in the laboratory, by glimpses of the researches in progress, and by constant reference to the original sources. Diminish the distance between professor and pupil; both are students, and both should be fed on the same intellectual diet. There is but one way to get and keep an education. Demand of every student a written discussion of some very limited thesis, giving the results of the original investigators, together with any observations the student has made for himself. Give the more capable students opportunity for original experimental work. Towards the end of the instruction, when the student is ripe for such work, offer a liberal number of courses of didactic lectures with demonstrations. Let each course consist of from one to four lectures not more than forty-five minutes in length, presenting all that is known of the chosen subject. These lectures should show the student the historical development of scientific problems, the nature of scientific evidence, and the canons of criticism that help to sift the wheat from the chaff of controversy. From the beginning to the end of the instruction hold fast to concentration, sequence and election. Such are the lines along which sound theory would direct the teaching of physiology in medical schools.

Concentration, sequence and election are the safeguards of economical labour.

Whether the student's time is to be given wholly or only in part to the subject taught is the first problem to be solved in planning the actual instruction. Men in training for professional physiology commonly concentrate their energies for a sufficient period on this one subject; and this is regarded as the most economical way of mastering any science, for the ground gained by one day's work is still fresh in the mind when the next day's work begins, and continuity of thought is not disturbed. The plea that the instruction in one subject should be broken by the study of other subjects in order that the instruction in each may have "time to sink in" need not be entertained; experience shows that much of it sinks in so far that it cannot be recovered without the loss of valuable energy. A more serious objection is that the method of continuous application is highly fruitful in men of exceptional powers, who are keen in spite of protracted effort, but is wasteful for the average brain, which is fatigued and unreceptive after some hours of unremitting labour. The truth of this must be allowed; but the objection does not apply to wide-ranging sciences such as anatomy and physiology, which are not narrow, hedged-in areas, but which consist rather of broad and diversified domains composed of many contiguous fields, the varied nature of which is a perpetual refreshment.

A correct sequence of study is also highly important. Very often in medical schools the lectures in physiology are given before the student has any acquaintance with the anatomy of the structures considered, and still more are heard before the student has any true anatomical knowledge—that based on actual contact with tissues and not upon a glimpse of a distant prosection or a hasty glance at a diagram. Similar instances are not uncommon in later parts of the curriculum. The natural sequence demands that the study of structure should precede the study of function, and the study of the normal precede that of the abnormal. Thus the natural order of medical study is descriptive anatomy, physiology, pathology and medicine. There is a considerable advantage in treating organs individually, studying their structure, physiology, pathology, diseases and treatment in continuity, but practical difficulties in arranging such a course make this inadvisable.

Election is correct in theory and unavoidable in practice. Generations have passed since it was possible to teach every clever student all things. Yet in many schools the effort is still made. The herd of students is driven hastily past the monuments of genius and learning in the hope that they who run may read. Students are exhorted to be great, while littleness

is thrust upon them. The obstetrician and the ophthalmologist still receive the same instruction. It is obvious, however, that this indiscriminate gorge will be soon an unpleasant memory. The wonderful growth of medicine is breaking bonds already centuries old. All minds in one mould is ceasing to be the ruling axiom in medical teaching, not because it is a terrible delusion which by retarding discovery has cost the lives of countless thousands, but because it is no longer practical. Success demands some acquaintance with all subjects and an intimate knowledge of one. Day by day the walls rise higher between one speciality and another. The parting of the ways begins at the threshold. In anatomy, physiology and pathology the student should spend his time on those portions which are directly associated with his future work as practitioner or investigator.

This early election will be strenuously resisted by partisans of the tradition. They will contend that the present instruction embracing the entire field is known to give a very inadequate acquaintance with the subjects taught; therefore, instruction covering only a part of the ground will give still less. The argument is beside the mark. The present method of instruction would be inadequate in any event. The medical degree is granted for superficial information in twenty-five or thirty subjects. The sign of the scholar and man of science, namely, thorough knowledge of some one field, is wanting. Yet this training of the man of science is more and more necessary for success. Moreover, a thorough training in at least one subject increases the power of acquiring the fundamental data of related subjects while it protects the mind against superficiality. A further necessity for election is seen in the fact that the great medical schools are university departments. They are attended by an increasing number of men who will never practise medicine but will become investigators in some branch of biological science.

Following the idea of concentration, sequence and election, I have proposed that the student's undivided attention be given to one principal subject at a time. The principal subjects in medicine are anatomy, physiology, pathology and clinical medicine including surgery. The four years' course in medicine is divided into eight terms or semesters, which usually comprise sixteen weeks of instruction. The first of the eight terms may be given to the primary course in anatomy, including histology; the second to the primary course in physiology, including physiological chemistry; the third to the primary course in pathology, including bacteriology; the fourth to pharmacology, clinical chemistry and physical diagnosis; and the four remaining terms to clinical medicine and surgery. The primary courses just mentioned provide the instruction in anatomy, physiology and pathology which every student is advised to take. Advanced instruction in these subjects may be offered in subsequent elective courses.

To meet the needs of the several classes of students found in universities the department of physiology must provide: (1) The primary course already mentioned, suitable for every student of biological science, including medicine; (2) An advanced course, intermediate between the primary course and research; this advanced course will be taken by candidates for the degree of Doctor of Philosophy who have selected physiology either as their principal subject or as one of the two or three subordinate subjects required of such candidates; (3) Opportunities for physiological research.

The primary course in physiology is held from 9 a.m. to 1 p.m. daily during the second term of four months in the first year of the medical curriculum. The afternoons of these four months are devoted to physiological chemistry. The primary instruction in physiology is divided into three parts. Part i., of five weeks' duration, provides thorough experimental work in some limited field. In this, the student should acquire the point of view, the general physiological method, training in technique, and a complete knowledge of one or more tissues to serve as an introduction to the physiology of the remaining tissues. There can be little doubt that the physiology of muscle and nerve should be chosen for this purpose. It is the most fully developed chapter in physiology, and is well adapted to train the mind in habits of exact experimentation and close reasoning. Moreover, the physiology of muscle and nerve is in large measure the physiology of all living tissues, so that a man learned in this one field is in effect already acquainted with the general principles of physiology. Part ii., of about seven weeks' duration, comprises carefully arranged fundamental experiments, giving in turn the elements of each field in physiology except that of nerve and muscle, which has just been studied. In part iii., covering the remainder of the term of sixteen weeks, the instruction is divided into special courses on the physiology of the eye, ear, larynx, digestion, the spinal cord, the innervation of the heart, &c. Each course is long enough to include all the practicable experiments that should find a place in a systematic, thorough study of the subject. The number of such experiments, and hence the length of the special courses, is naturally different in the various instances; thus the experimental physiology of the eye occupies more time than the physiology of the larynx. The student may elect the subjects that most interest him, but must choose a sufficient number to occupy him during the entire four weeks of instruction. In planning these courses the aid of distinguished specialists is sought.

Each student is required to present one written discussion of some small and sufficently isolated thesis, giving the work of the original investigators. The way of dealing with the sources at first hand is thus learned. Many of these essays are read and discussed before the class. The discussions begin with the sixth week of the course and are held daily during nine weeks. None is held during the last two weeks. The literature of each subject is divided into two portions and each is assigned to one man. The fifty-four subjects, therefore, are presented in one hundred and eight essays. The men chosen for this purpose are the best in the class; their choice is determined at first by the results of their examinations in anatomy, and, so soon as practicable, by the results of their work in physiology. In addition to the two men who read theses, one or more of the investigations on each subject are studied by four men, who are thus specially qualified for the discussion. The four are selected in turn from the whole class. To illustrate, let us take as an example "The Transmission of the Cardiac Excitation Wave." One student defends the theory that the cardiac excitation wave is transmitted through muscular tissue; a second defends transmission through nerve tissue. Each presents a carefully written account of the evidence pro and con. The four men, each of whom has read at least one of the investigations on this subject, lead the discussion, which is held by the entire class and the departmental staff. The subjects chosen for discussion are, as a rule, such as cannot be fully studied in the laboratory. Thus the discussions complement the remaining instruction. The subjects to be discussed are bulletined before the appointed day so that the class may come to the discussion somewhat prepared.

In the last two weeks of the course, students who have performed their experimental work especially well may elect instruction in physiological research. The subject chosen must necessarily be very narrow, and, where possible, should be one the literature of which has been already examined in the preparation of the student's thesis. Experience has shown that after fourteen weeks of strenuous labour in experimental physiology, the student of average ability learns to work rapidly and carefully, so that much can be accomplished in two weeks of experimentation in one small subject. Even a very brief experience of investigation is of the greatest value and interest. Examples of subjects suitable for training in investigation are: "The Compensatory Pause;" "The Tetanus Curve;" "The Action of Calcium and Sodium Ions on Rhythmic Contractility."

Beginning with the second week of the course, a daily written examination, twenty minutes in length, is held. One or, at most, two questions are asked. They concern the student's own experiments. The purpose of the examination is to cultivate precision in statement. The emphasis which the question gives imparts a correct perspective. Further, the examination reveals men whose indolence or incapacity marks them for special care. The following questions are some of those asked in such examinations: "Give experimental evidence to show where stimulation begins on the closure of the galvanic current. Explain the difference between the stimulating electrodes and the physiological anode and kathode in the stimulation of human nerves. Give the experimental basis for an explanation of the auriculo-ventricular interval."

The didactic instruction consists of a ten-minute talk in the laboratory, commenting on the examination of the previous day and explaining any special difficulties in the experiments, and of a daily lecture. In every instance this lecture is intended to discuss experiments. Wherever possible the experiments are to be performed by the students themselves before coming to the lecture. Experiments which the students cannot do for themselves

are studied by them from the original protocols, furnished with a suitable explanatory text. Thus the fundamental elementary information is gained from the original sources before the lectures. The students are questioned concerning these fundamental experiments. The questions are arranged in the sequence required for a systematic presentation of the subject. Wherever necessary, the lecturer adds from his own stores to the information already possessed by the student. The class is encouraged to question the lecturer concerning matters not quite clear. At the close of the exercise the lecturer sums up briefly. The end in view is the development of the mind rather than the imparting of information. For example, the fact that the pressure of the saliva in the ducts of the submaxillary gland during secretion is higher than that of the blood in the carotid artery is not presented as a fact to be memorised, but is discussed with reference to its bearing on secretion by filtration; the student has learned the fact itself from the original source before coming to the lecture. Some of the lectures on special subjects, such as the eye, are given by distinguished specialists in practical medicine. Each instructor gives as an elective one or more lectures describing, with demonstrations, his own investigations; the investigator discussing his own experiments is a powerful intellectual stimulus; too little account has been taken of this educational force.

The student should be provided with what may be called a laboratory text-book. This text-book consists of a series of experiments and observations, taken from the original sources, and arranged in the sequence suited to develop the subject. Very often the historical sequence serves this purpose best. The description of the experiment follows the original so far as practicable. The experiments are provided with a suitable commentary text. The student is made to feel at every step that physiology is an experimental science, that the only material proper for discussion consists of observations and experiments free from error, and that safety demands constant reference to the original source. The laboratory text-book is supplemented by the student's laboratory note-book, in which the student preserves the graphic records of his experiments and the notes of his observations.

Little need be said concerning the instruction intermediate between the primary course and research. In the intermediate course the experiments chosen for the individual student vary with his goal, and are arranged in the order that seems best adapted to train the mind for research in the direction desired.

The methods of primary and advanced instruction here presented are obviously the methods of the investigator. They can be carried out effectively only by those whose chief purpose is the advancement of human welfare by discovery. In many schools, instructors are still selected mainly because they can talk agreeably of the work of others; in some, the instructor must have made one experimental study in the subject which he teaches; in a very few of the large schools, the higher positions are occasionally bestowed on men to whom research is more than a memory, but these positions almost invariably are burdened with a mass of petty administrative detail. The university devotes these men to researches which the university prevents them from making. Thereby its best minds are set to its lowest work. A change is necessary here. No man who has not made at least one experimental investigation should be appointed assistant in a department of physiology, no man who has not shown marked capacity for original work should be made instructor, and the professor's chair should be filled only by those in whom the ardour of discovery is not likely to be cooled by the advancing years. At least half the day should be set aside for research, and the hours thus reserved for the highest studies should be guarded against every encroachment. The best elementary instruction can be given only in the atmosphere of research. Discovery fires the imagination of youth, consoles the aged, and lifts the mind from mediocrity to greatness.

W. T. PORTER.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The following is the text of the speech (composed by Mr. A. C. Clark of Queen's College) delivered by Prof. Love in presenting Principal Lodge for the degree of D.Sc. *honoris causa* on February 12:—

Adest Oliverus Josephus Lodge, Naturæ rerum indagator acerrimus. Qui, ut vitam eius brevissime percurram, iam quinquaginta abhinc annos natus in Collegio Universitatis Londinensis primo institutus, in Universitate Londinensi gradum Doctoris Scientiæ adeptus est: mox in Collegio Universitatis de Liverpool Professor Physicæ creatus summa laude viginti annos floruit: anno denique proximo Universitatis novæ de Birmingham primus Præses factus est. Magna iamdudum fama inclaruit hic vir, quod in rebus physicis experimentorum longum ordinem peritissime commentus est et felicissime confecit: quo in genere sæpe numero ei contigit ut re acu tacta difficillimam aliquam quæstionem, in qua hæserant doctissimi Physicæ auctores, felicissime explicaret. Primo quidem quæ et qualis sit vis illa Naturæ moderatrix, quam ἐνέργειαν vocant, quibus mutationibus utatur, quærebat, neque laborum laude debita diu caruit a Regali Societate iam tredecim abhinc annos Sodalis electus. Iam tum vestigia Fitzgeraldiana secutus radiorum electricorum naturæ studere inceperat. Docuerat enim Maxwell, huius rei peritissimus, vim electricam oscillationibus quibusdam per inane spatium transferri posse, quo duce usi apud Germanos Hertzius, apud nostros Lodge, harum oscillationum signa et indicia certa deprehendere conabantur. Hertzium quidem ad metam primum pervenisse non nego, ad quam tamen Lodge eandem viam ingressus certo cursu ferebatur: illud vero affirmaverim veritate ab Hertzio patefacta hunc meliorem viam quærentibus monstravisse et novæ doctrinæ prædicatorem insignissimum exstitisse. Neque civium utilitatibus non inserviebant eius labores, cum in nuntiis artē telegraphica sine filo metallico mittendis, tum in fulminibus avertendis et in postes aeneos, tectorum nostrorum tutamina, sine fraude derivandis. His denique diebus magnam rem felicissime aggressus est cum quæreret de terræ cursu per medium illud ætherium, quo lux et vis omnis electrica et magnetica pervehitur, et doceret hoc medium, quod vocant, penitus stagnare et materiæ crassioris motibus omnino carere. Multum denique profecit in natura radiorum illorum explicanda quos Lenardus, Röntgen, Zeeman, viri acutissimi, primi detexerunt. Insignem eius operam in his variis generibus agnovit Universitas Sancti Andreaa, quæ gradu Legum Doctoris, et Regalis Societas quæ numismate aureo Rumfordiano eum iure ornavit.

Neque id silendum arbitror quod huic viro intima Naturæ penetralia reserare nequaquam satis erat, sed et in tironibus instituendis et in rebus gubernandis pari industria et felicitate eminuit: quo in genere haud parvam partem laudis suæ debet Universitas de Liverpool, de qua optime meritus est. Huius viri ingenio multiplici latior profecto campus iam datur, cum Universitatis novæ de Birmingham Præfectus sit.

The Junior Scientific Club held their 221st meeting on Friday, February 15. Mr. W. B. Croft, M.D., of Pembroke, read a paper on "The management of light waves," which was followed by a paper by Mr. A. C. Inman, of Wadham, entitled "René Descartes, and his physiology."

Mr. R. E. Baynes, Lee's Reader in Physics, has been appointed a delegate of the University Museum, in place of Sir John Conroy, F.R.S., deceased.

The Provost of Oriel (D. B. Munro) and the President of Trinity (H. F. Pelham) have been appointed representatives at the ninth Jubilee of the University of Glasgow.

CAMBRIDGE.—Mr. W. D. Niven, F R.S., has been appointed an elector to the Cavendish professorship of experimental physics.

THE *American Naturalist* for January gives a list of gifts and bequests made to various educational institutes in the United States for eleven months of the year 1900, ending November 30; they amount to over sixteen million dollars. The largest amount is a gift, not to exceed three million dollars, from Mr. Andrew Carnegie, for the enlargement of the Carnegie Institute, Pittsburg, Pennsylvania. The number of gifts or bequests recorded is about eighty.

THE report of the Technical Education Committee of the Derbyshire County Council shows that continued progress is being made in the provision of adequate laboratory and workshop accommodation in important centres of the county. In the department of agriculture, the headquarters of the agricultural teaching have been transferred from Nottingham to the farm centre at Kingston, where additional buildings have been constructed to enable practical science work to be carried on.

THE Senate of the Royal University of Ireland has passed the following resolution:—"That in the opinion of the Senate the